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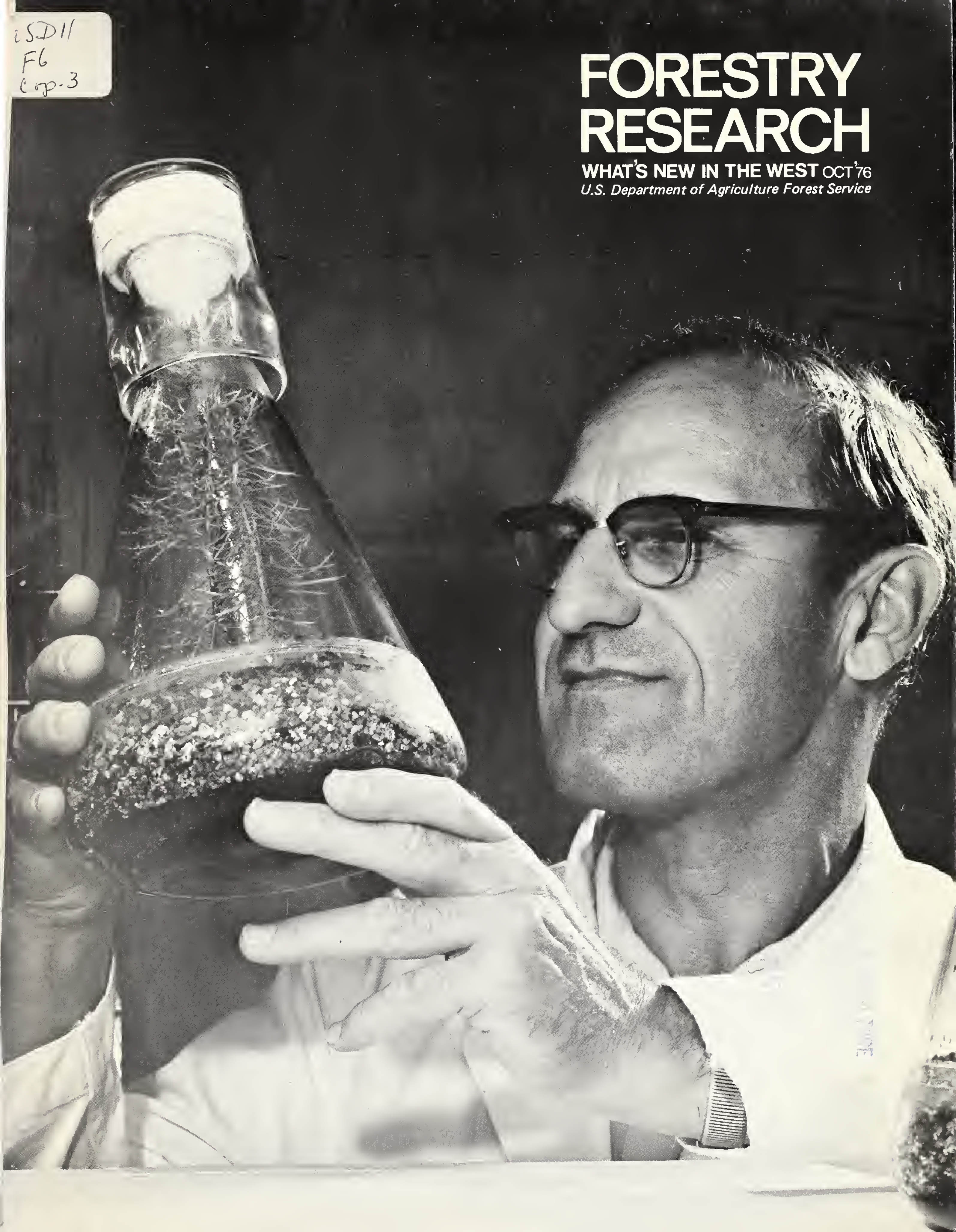
FORESTRY RESEARCH

WHAT'S NEW IN THE WEST OCT '76

U.S. Department of Agriculture Forest Service



a note to you

Forestry Research: What's New in the West, is a report on the work of the USDA Forest Service's four Forest and Range Experiment Stations in the West. These research centers, and the States included in their areas of study are: Rocky Mountain (North Dakota, South Dakota, Nebraska, Kansas, Colorado, Arizona, New Mexico, and part of Wyoming, Oklahoma, and Texas); Intermountain (Montana, Idaho, Utah, Nevada, and part of Wyoming); Pacific Northwest (Alaska, Oregon, and Washington); and Pacific Southwest (California, Hawaii, and the Pacific Basin).

on the cover

Bratislav Zak, recently retired PNW plant pathologist, grew seedlings in a laboratory growth chamber. See "An Underground Boost for Seedlings" on the facing page.

our addresses

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An underground boost for seedlings

Mycorrhizae surround the roots of a Douglas-fir (magnified 5 times).

Several thousand tree seedlings recently planted by Weyerhaeuser Company in Washington and Oregon are fighting for survival on forest sites where regeneration has been extremely difficult. Researchers are watching them closely to see whether they will establish the new roots they need to survive and grow.

The seedlings, planted in the spring of 1976, are Douglas-fir, ponderosa pine, and western hemlock. Because of research, they may have a chance to become established where others have failed. Before being planted on Weyerhaeuser tree farms, they were given a boost with a specially selected mycorrhizal fungus. The seedlings started life in the laboratories and greenhouses of the Pacific Northwest Forest and Range Experiment Station in Corvallis, Oregon. They grew from seeds planted in containers of vermiculite and peat moss, to which a mycorrhizal fungus had been added.

Mycorrhiza literally means "fungus root." Fungi capable of forming a symbiotic or mutually beneficial relationship with trees are known as mycorrhizal fungi. These fungi form mantles around the roots of plants and assist them in three important ways: (1) they help the roots absorb nutrients and water, (2) they protect the trees from harmful fungi, and (3) they produce growth regulators that foster increased growth and prolong the life of rootlets.

Cooperative study

In 1974, Weyerhaeuser and the Pacific Northwest Station began a cooperative study to find out whether reforestation success on hard-to-regenerate sites could be significantly improved by inoculating container-grown seedlings with mycorrhizal fungi. The Weyerhaeuser study was designed by Bratislav Zak, PNW plant pathologist, recently retired. He worked closely with Donald H. Marx, project leader for research on soil-borne organisms at the Southeastern Station, in planning the study. Southeastern Station researchers had successfully introduced mycorrhizal fungi into nursery beds, but no one had tried inoculating seedlings for planting in the Douglas-fir region.

The initial phase of the Northwest study established inoculation methods, growing medium, and fertilizer levels. Then the seeds of ponderosa pine, western hemlock, and Douglas-fir were planted in individual containers of vermiculite and peat moss inoculated with a pure culture of one of four species of mycorrhizal fungi. The fungi, isolated in the laboratory from fresh mushrooms, were selected because they are widely distributed in western forests and can be grown in laboratory cultures. One of the species is prominent in Douglas-fir forests; the other three are commonly found under ponderosa pine and western hemlock as well as Douglas-fir.

The seedlings grew in their containers in the Corvallis lathhouses for about 6 months before they were planted on Weyerhaeuser tree farms near Mt. St. Helens, Washington, and Klamath Falls, Oregon.

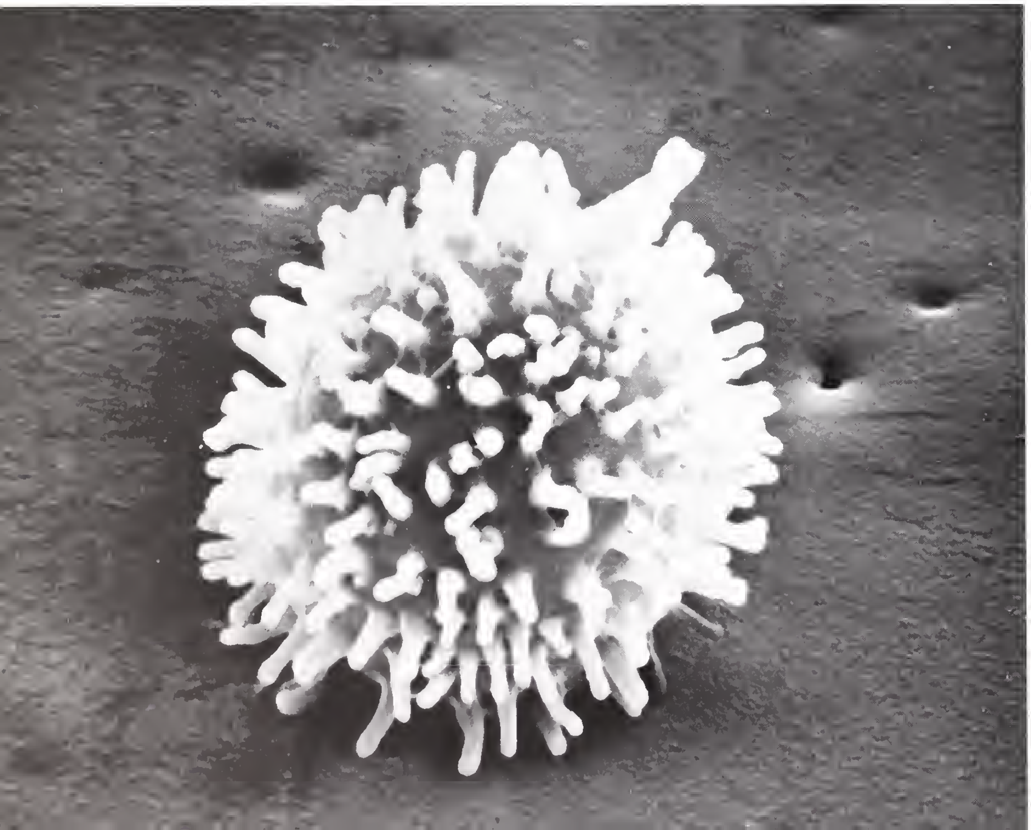
Before the study is completed, several thousand more seedlings will be inoculated with other fungi before being planted. When measurements of seedling survival and growth on the tree farms are completed in 1978, researchers will be able to tell foresters which of the mycorrhizal fungi tested best aid seedling establishment on hard-to-regenerate sites in Northwest forests.

Fungi importance

Although the concept of mycorrhizae was advanced as early as 1842, Mycologist Jim Trappe, project leader for research in tree root symbiosis and current director of the Weyerhaeuser study, has found that it is not generally well understood

The fruiting body (mushroom) of a mycorrhizal fungus has emerged under an innoculated Douglas-fir seedling.

A spore produced by the fruiting body of a mycorrhiza fungus (magnified 3,000 times).



by foresters and others who are responsible for reforestation programs.

Researchers have known for some time that all economically important forest trees and most forage plants need mycorrhizae for survival and satisfactory growth.

The importance of mycorrhizae has been demonstrated by the failure of exotic trees to flourish when planted in distant parts of the world. However, when suitable mycorrhizal fungi have been added to nurseries or planting sites, the survival and growth of these trees have improved dramatically. Similarly, on mining spoils, areas never forested, or those where trees have been absent for a long time, naturally seeded plants usually die unless spores of mycorrhizal fungi carried by air or animals are washed into the soil.

In the forest, mycorrhizae develop when the growing roots of a seedling encounter spores or mycelium of mycorrhizal fungi. The spores germinate and the growing fungi surround the roots. However, if this process is delayed, a seedling's roots may be invaded by harmful fungi. If the seedling survives, it may be stunted. Some seedlings will grow without mycorrhizae in the nursery, provided they are given sufficient nutrients and pathogens are controlled. But, when seedlings are planted in the forest, the mycorrhizae are essential.

Fungi development

Researchers have also found that mycorrhizal fungi vary in their environmental requirements. Some tolerate a wide range of conditions; others do not. Mycorrhizal fungi may unite with roots of seedlings growing in nursery beds, but if these fungi are not adapted to the sites where the seedlings are planted, they may not function or may even die. If that happens, the seedlings also will die unless they contact mycorrhizal fungi native to the planting site soil.

The ways mycorrhizal fungi reproduce are significant for forest management. Although most mycorrhizal fungi live in the upper few inches of soil, some surface to reproduce. Miniature mushrooms and toadstools are formed underground. At the proper stage of development, they suddenly take on water and push their way through the soil surface to expand and discharge their spores. The spores are carried by the wind and washed back into the soil by rain. Other species, such as truffles, reproduce underground. Small animals, attracted by the odor of the truffles, eat the fruiting bodies, but, the spores are not digested and are excreted in their fecal pellets. Squirrels, mice, and voles traveling from forested areas to newly planted clearcuts distribute spores of fungi to the benefit of new seedlings.

Several forest management practices deplete mycorrhizal fungi in the soil, Trappe says. The most important are elimination of host plants and drastic soil disturbance. Heavy timber cutting and slash burning can reduce fungi populations. Some pesticides may also destroy them. Eliminating truffle-eating small animals from newly planted areas is likely to reduce the number of fungal spores available for forming mycorrhizae.

Continued research

Until the ecology of mycorrhizae is better understood, researchers will not be able to recommend changes in forest management practices. However, if seedlings can be supplied with suitable fungi before they are planted, the depletion of local fungi by management practices will not be of critical importance. Much remains to be learned about mycorrhizae, especially in forestry. The part of the forest ecosystem that exists above ground has been studied in great detail. Much less is known about the underground organisms (roots, animals, and microorganisms), even though their biomass is as great as that above ground and as important. For example, most plants have been adequately classified, but many mycorrhizal fungi have not and cannot even be identified. Trappe believes that classification is vital to research and is now devoting part of his time to this essential task.

The Pacific Northwest Station is one of several public agencies in Corvallis now engaged in mycorrhizae research. Others include the Ornamentals Laboratory of the Agricultural Research Service and the Departments of Botany and Plant Pathology, Horticulture, Soils, and Forestry at Oregon State University. In May 1976, the University, in collaboration with the Pacific Northwest Station, received a grant of $146,000 from the National Science Foundation for a 2-year study of the role of mycorrhizal fungi in nutrient capture and cycling in Douglas-fir ecosystems.

At present, probably more people are involved in mycorrhizae research in Corvallis than anywhere in the world. "It is important that a sizable portion of forestry research be devoted to figuring out how a forest works," Trappe says, "because such knowledge will lead to better forest management practices."

— By Dorothy Bergstrom, Pacific Northwest Station

P2V aircraft with experimental tank and gating system being prepared for tests.

Refining fire retardant research

Air tankers are a key tool in fast, efficient forest and range fire control. Researchers at the Intermountain Forest and Range Experiment Station's Northern Forest Fire Laboratory at Missoula, Montana, are striving to provide fire managers with systems and guidelines needed to improve the success of air tanker operations.

Fire control agencies in the United States currently use about 20 million gallons of retardant annually in suppressing wildfires. Retardant costs exceed $5 million a year and their delivery and application add another $20 million to the bill. Significant savings can be realized by increasing the effectiveness of the chemicals, improving methods of delivery and application, and refining strategy and tactics through the use of operational guidelines. At the same time, detrimental impacts on the environment, as a result of retardant drops, must be minimized.

The Fire Control Technology Research Work Unit at the Northern Forest Fire Laboratory, is determining the chemical and physical properties of retardants that will give the best fire control results under an array of fuel, fire behavior, and environmental conditions. Project Leader Charles W. George, Research Forester Aylmer D. Blakely, and Technician Gregg M. Johnson have compiled "Forest Fire Retardant Research: A Status Report," which summarizes 57 laboratory and field studies that have helped to develop retardant performance standards. The report also discusses current and planned research.

Retardant research at Missoula is organized into five study areas: effectiveness, physical properties, delivery systems, corrosion, and environmental impact. Numerous, interrelated studies are being conducted by Forest Service researchers, by contractors, and through cooperative agreements with State and other Federal agencies.

Model developed

One of the most valuable research tools for studying the physical properties and effectiveness of retardants is a computer model designed for the Forest Service by Honeywell Incorporated of Hopkins, Minnesota. This model is used to assess the fire control value of various retardant characteristics such as droplet size, film thickness, salt content, concentration, and application amounts.

Laboratory and field studies will refine and verify the model by providing estimates for the amounts and kinds of retardants needed to control fires under various fuel and burning conditions. Control effectiveness for specific fuel types such as grass, brush or timber, and the associated behavior of fires in these types, will be determined.

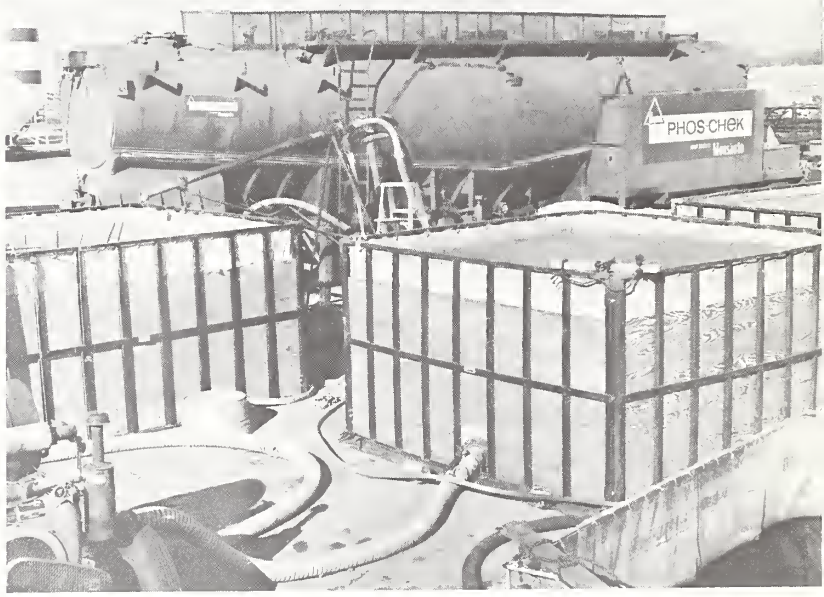
In addition, the model will be expanded to evaluate how well retardants actually "extinguish" a blaze, or simply "retard" its progress. The "extinguishing" and "retarding" functions of retardants will be defined separately, and in combination. They also will be related to the method of delivery and to the physical characteristics of each retardant.

Assessing fire retardant delivery systems has been a major Intermountain Station effort. At Chico, California, during the fall of 1975, Station researchers and California Division of Forestry personnel cooperated in field tests of an experimental aircraft tank and release system developed by Honeywell. The 2,000-gallon tank, capable of being pressurized, was instrumented to permit controlled experiments on the release of retardants and to note changes that took place in the chemicals and their dispersion during drops. Scientists were able to regulate the size and duration of drop gate openings, the tank pressure, and the kinds of material drawn from any of the tank's nine compartments; all factors affecting the physical characteristics of retardants upon release.

Field tests

Aircraft drop heights and speeds, retardant paths, and retardant breakup were determined from action photos taken with high-speed cameras. A ground crew collected retardant samples reaching some 2,000 cups placed throughout the drop zone to measure retardant distribution and concentration.

Gregg Johnson, Technician, checks fill gauge as experimental tank and gating system is filled with retardant.



Portable mixing plant used at Chico for ETAGS testing.

Project Leader George says information from the field tests will lead to the development of models which can be used to determine the performance of present air tankers as well as provide specifications for future retardant delivery systems.

The fire technology team and Honeywell also have cooperated in the development of performance guides that will result in more flexible and efficient use of existing air tankers during fire control operations. Using the guides, fire managers can select the specific air tanker that

Project Leader Charles George checking one of the 2,000 cups placed to collect retardant during the Chico tests.

will be most effective for a local fire-fuel situation. They can also compare the performance of various types of tankers that might be brought into the operation.

The authors say the guides are not a panacea for all air tanker problems, but provide baseline values that should be refined by experience and experimentation.

Corrosion problem

Corrosion induced by retardants in air tankers and in ground support equipment has been a problem since the beginning of the retardant program.

Under a contract with the Forest Service, corrosion experts from the Ocean City Research Corporation, Ocean City, New Jersey, are assessing the effects of chemical retardants on mixing and delivery systems, particularly air tankers. They are determining the corrosion rates for critical alloys, and are correlating those rates with actual field damage. From this information, the Ocean City researchers are establishing corrosion prevention guidelines. Managers will be able to use the guides to prepare specifications for both retardants and equipment that will minimize the corrosion problem. They can also use the guides to devise better cleanup and maintenance techniques to prolong equipment life.

The effect of firefighting chemicals on the environment has been a concern of fire control officials since retardants first came into use.

Past experience indicates that fire retardants mainly affect water quality, and thus fish and other aquatic life. The Intermountain Station recently published a system for computing quick, general estimates of potential fish kill if fire retardants are released into streams during firefighting operations. The system enables the land manager to decide, before a retardant drop is ordered, whether or not the immediate fire control need is great enough to warrant possible fish losses.

Research continues

A cooperative study with the Pacific Northwest Forest and Range Experiment Station is underway to determine the short- and long-term effects of parallel and cross-stream retardant drops on water quality and underwater plant and animal life. The study also will include an evaluation of the effects of retardant chemicals on forest soils and plants.

For centuries, forest and range fires have been extinguished with water and soil. Through research, new methods are being developed and refined to provide for more effective fire control. Intermountain Station's fire technology team is playing a key role in assuring that these techniques meet the needs of today's world.

If you would like to know more about the Missoula team's studies, write to Intermountain Station for the following publications:

George, Charles W., Aylmer D. Blakely, and Gregg M. Johnson. 1976. Forest Fire Retardant Research: A Status Report. USDA For. Serv. Gen. Tech. Rep. INT-31-FR8. 22 p.

Swanson, D. H., C. W. George, and A. O. Luedecke. 1976. Air Tanker Performance Guides: General Instruction Manual. USDA For. Serv. Gen. Tech. Rep. INT-27-FR8m 19 p.

Van Meter, Wayne P., and Charles E. Hardy. 1975. Predicting Effects on Fish of Fire Retardants in Streams. USDA For. Serv. Res. Pap. INT-166-FR8 16 p.

— *By Delpha Noble, Intermountain Station.*

Endangered: mountain air

Air pollution and the value of clean air are of growing concern to owners and managers of mountain lands. The mountains attract accelerating numbers of people seeking a wide variety of recreational experiences, all of which have some degree of impact on the land. They bring with them fossil fuels — oil, gas, and coal — for transportation, heating, and cooking; all are major sources of air pollution. Ironically the very values people seek, such as scenic beauty and clean air and water, are those in the greatest danger of being lost.

According to Doug Fox, project leader for Forest and Mountain Meteorology research at the Rocky Mountain Forest and Range Experiment Station, two pollutants are receiving widespread attention in mountain areas. They are carbon monoxide (CO) and total suspended particulates (TSP) — the mass of particles in the air at any given time.

The amount of CO emitted, mostly from automobiles, depends on the roads driven, traffic encountered, driving habits of the motorist, and maintenance of the engine. Because engines operating at high elevations receive less oxygen, combustion becomes less efficient, and emission of CO is greater than at lower elevations. Although carbon monoxide is also emitted from other types of combustion, primarily heating and cooking with wood, coal, oil, and gas, this facet of emission rarely becomes a major factor in the air quality picture.

Total suspended particulate (TSP) is made up of those particles emitted directly into the air and those generated by chemical reactions between gases in the air. Emitted particles include road

A vivid example of particulate pollution in a popular ski resort valley.

dust, volcanic ash, and smoke from fireplaces, campfires, and wildfires.

The reaction-generated particles, which are smaller than emitted ones, create a more intricate problem, and occur in obviously polluted as well as apparently clean air. Although the details are complex, atmospheric reactions between hydrocarbons, nitrogen oxides, sulfur oxides, and ozone are responsible for accumulations of these so-called secondary particulates in such forms as man-caused smog or natural haze.

EPA levels

Increasing development of recreational facilities seems inevitable, particularly on private forest lands, resulting in the probability of more CO and TSP entering the air. As population pressures grow in the mountains, the need arises for quick, easy, yet accurate methods of identifying potential problem areas. However, an acceptable air quality level must first be established as a base from which predictions and decisions can be made.

Existing national standards of pollution are based on human health and welfare. The Environmental Protection Agency has proposed a three-level classification scheme in which Class III allows particulate pollution up to the national standards; Class II allows accumulation up to 12 percent of the national standards; and Class I, designed to permit no significant deterioration of the currently existing air quality, allows particulates to accumulate to only 4 percent of the standards.

The job of classifying air quality standards in mountain lands is delegated to State and Federal land managers in concert with involved publics. As part of standard setting, managers must identify areas where problems are likely to arise. But how? This is the job Fox and his meteorology team, based at Fort Collins, are setting out to do.

Limited data

Fox says one of the first challenges in detecting possible pollution areas is determining the interactions between local climatic conditions, terrain and surface features (trees, buildings, etc.), and land uses. While data on topography and land uses can usually be found, climatic data for mountain areas are limited, and knowledge of existing air quality is virtually nonexistent.

The absence of sufficient climatic data has led the research group to develop computer models and other techniques to calculate missing information about wind currents and the ability of these winds to mix pollutants in given locations. Meteorologist Mike Fosberg has designed a mathematical model that calculates the airflow pattern in areas of complex topography. A theoretical description of this method is found in "Estimating Airflow Patterns Over Complex Terrain" (Research Paper — RM-162-FR8), available from the Rocky Mountain Station.

Fosberg and Fox are currently researching techniques to calculate the dispersing, or mixing capabilities, of mountain winds. Working with Professor William Marlatt of the Earth Resources Department at Colorado State University, Fosberg and Fox developed a set of "air pollution potential maps" for the Central Rocky Mountains. These maps combine calculated airflow patterns with the ability of the atmosphere to disperse pollution. The research group is working to simplify both the development and use of the maps for practical field application.

A recent development relates the maps to a proposed universal pollutant index. This index will simplify air pollution ratings by eliminating technical formulas and chemical notations. It will allow land use planners to readily determine the level of human activity allowable within the constraints of pre-specified air quality standards.

Weather library

Establishing the National Fire Weather Library is another important step taken by Meteorologist William R. Furman and Computer Programmer Glen E. Brink to fill the void in mountain climatic data. This library is a collection of computerized historical weather information maintained at the Department of Agriculture Computer Center in Fort Collins. Data from over 800 Forest Service fire weather stations throughout the country are fed daily into the system. Access through field computer terminals allows interested individuals to obtain this information.

Library data are useful for planning a variety of management actions such as fire suppression, slash burning, prescribed burning, and preparing environmental impact statements. For more information on this system, a publication entitled "The National Fire Weather Data Library: What It Is and How to Use It" (General Technical Report — RM-19-FR8) is available from the Rocky Mountain Station.

In yet another effort, the meteorology team is monitoring weather and pollution conditions in a very real situation. Vail, Colorado, is the site for this cooperative work with Colorado and Utah State Universities. Vail was selected both for meteorological and topographical reasons and because it has, and is, undergoing rapid development as a major ski resort. Air pollution is a growing concern there and is related to weather conditions that are especially prevalent during the winter months.

Rocky Mountain scientists established six weather stations to continuously measure windspeed, direction, and air temperature, thereby developing initial information on windflow patterns at ground level in Vail Valley.

A tethered balloon, provided by the National Center for Atmospheric Research for use by Dr. Thomas McKee and other cooperators at Colorado State University, was flown last winter to record and transmit vertical wind and temperature profiles. Dr. Gene Wooldridge and his Utah State University associates released several types of weather balloons. Tracking these balloons, which drifted with the air currents, allowed researchers to compile preliminary information on the windfield above Vail.

This cooperative program has gathered valuable preliminary information on the nature of wintertime meteorological processes and windfield patterns in mountain valleys. These data are helping Rocky Mountain Station researchers design mathematical models of the wintertime circulation patterns and temperature structures in the mountains.

Personnel from Colorado State University and the National Center for Atmospheric Research operating a tethered balloon.

Solving the problem

While research is underway to obtain better information on mountain weather processes and their effects on air quality, what is being done to solve existing and potential problems? Fox says there are essentially two approaches: the first is active management of current situations; the second is passive management through planning to cope with problems before they arise. The active side involves efforts to correlate polluting activities with proper meteorological conditions. Analyzing airflow patterns prior to residue burning has proven successful in a smoke management program operated by the Forest Service in the Pacific Northwest. On a smaller scale, limiting activities like auto and fireplace use in mountain resorts can be encouraged when severe air stagnation is likely.

However, Fox believes the passive approach, through proper recognition of impending problems, offers the greatest potential for success in controlling mountain air pollution. Air quality should be recognized as a component in the earliest stages of land use planning. Only then can development patterns be designed to minimize air quality impacts. The goals of the Forest and Mountain Meteorology team at Rocky Mountain Station are (1) to simplify available methods and develop improved tools land planners and managers can use to assess pollution potential and, (2) to devise improved ways to manage mountain air quality before problems occur.

Persons interested in additional information on this research may contact Doug Fox at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, 80521, (303) 482-7332. (FTS # 323-5211)

— *By Rick Fletcher, Rocky Mountain Station*

Doug Fox studies pollution potential map overlays which help indicate possible problem areas.

Getting into FOCUS

Fire control specialists on 14 wildland areas in the U.S. are currently testing a system that pits their best fire control plans against hundreds of computer-simulated wildfires, and gives them a comparative analysis of how each plan would work during a real-life fire season. The system, called FOCUS (Fire Operational Characteristics Using Simulation), was developed by the Fire Management Systems team at the Pacific Southwest Station's Forest Fire Laboratory in Riverside, California.

To use FOCUS, fire planning specialists, working with computer specialists, carefully prepare a data base on a specific land area for the computer. This base includes the basic plan for initial attack on wildfires, possible alternatives to this plan, and information on wildfires that have occurred on the area in the past. With this information, the computer can simulate how the basic plan and the proposed options would work on real-life fires. Results for each alternative can be presented in terms of the probable size of fires, cost of putting them out, and damages expected. The administrator or administrative team on the unit can compare these results to the overall objectives for the unit, and decide which fire plan to use.

For example, fire control planners on the Clearwater National Forest in Idaho used FOCUS to test six options to their basic plan. These alternatives included whether or not:

- to add two large helicopters to their air attack force;
- to take out the helicopters, but increase the number of smokejumpers;
- to increase the number of smokejumpers, but decrease the size of fire crews on Ranger Districts. The FOCUS analysis showed that the most cost-effective option was to add two large helicoptors.

FOCUS can be used to simulate other proposed changes to the location, size, and strength of a fire control organization. For example, the user can find out what might result if the location of a fire station is changed, or if the number of firefighters in a hand crew is doubled.

Plan evaluation

"FOCUS is a way to avoid the traditional 'wait-and-see' dilemma in planning wildfire control," says Stan Rapp, research liaison forester between the Riverside researchers and fire control specialists in the National Forest system who are testing FOCUS. "Before FOCUS was available, you usually had to wait through at least one fire season to see how your plan worked. And, if you wanted to thoroughly test your plan, you'd have to use it for longer than that. Now, with FOCUS, once your data is fed into the computer, it only takes a matter of hours for you to get a printout showing how your base plan and options would probably perform during all the fire seasons you chose to simulate.

"FOCUS is not a way to develop strategy for fighting individual fires," he explains. "It is a tool for helping the planner decide on the best way to staff, equip, and operate a fire control organization."

Rapp says FOCUS is probably the most complex simulation model ever developed outside of the aerospace industry and the military. Details on weather, fuels, and topography have to be fed into the system, so that the simulations of fire spread will match real-life conditions on the planning unit. Also needed is information on procedures used to dispatch air and ground crews; location and capacity of roads and trails; location of helicopter bases, helispots, airtankers, airtanker bases, and other fire control equipment and facilities; number of firefighters available and the estimated rate at which they can construct lines to hold the fire; salaries, equipment fees, and other costs; and similar information. From this information, the computer simulates the minute-by-minute operations of the firefighters and equipment, and the buildup and suppression of lightning- and man-caused fires.

Operational testing of FOCUS on the Willamette National Forest: left, Bud Shea, computer specialist; right, Frank Lehto, fire specialist.

Expenses

So far, collecting and coding all this information has been the biggest expense facing FOCUS users. It takes about 6 to 9 man-months for the fire planning specialist and computer programmer to complete this job. After that, to run the base plan and five alternatives against 4 fire seasons costs about $500 to $1500 for computer time. Additional alternatives would cost about $20 to run. (These figures are based on charges to users of the Forest Service's computer center in Fort Collins, Colorado.)

Costs of keeping the information needed for the simulations current, according to Rapp, should be "very modest, and probably comparable to those of manual fire planning systems." Some units working with the system have reported a good return on these FOCUS investments. The Sequoia National Forest in central California, for example, found after a FOCUS analysis that a planned expenditure of $70,000 for equipment would not increase firefighting success enough to make this expenditure worthwhile.

Specialists

Fire management specialists play a major role in the FOCUS analysis, Rapp says. They are responsible for drawing up the base plan and alternatives, for selecting the fire seasons that the computer will simulate, and for recommending which plan to go with once the FOCUS analysis is completed. In addition, their judgment and experience is needed in predicting the behavior of a fire that is not contained by the time it burns 100 acres. The computer will simulate such an "escape" fire any time that the simulated fire burns too fast for the proposed initial attack force to contain it. The specialist's best estimate of the costs of these escape fires, the acres burned, and the damages — all obtained through standard gaming procedures — is added to the FOCUS analysis.

FOCUS is designed for use anywhere in the U.S. by any wildland management agency. The system can accommodate fire planning units from 250,000 to 10 million acres in size, depending upon the complexity of the road network on the unit. The National Forest System is learning how to apply FOCUS on Forests in California, Utah, Arizona, South Carolina and Michigan; operational tests have been completed on National Forests in Oregon and Montana. The State Division of Forestry in California is trying it out on the San Bernardino Ranger Unit in southern California, and has finished a FOCUS analysis on the Mendocino Unit in northern California. And, the Bureau of Land Management is learning the system in Montana, Alaska, and New Mexico.

Advantages

To these units, and others that will try FOCUS in the future, the system offers advantages to the fire planning specialist and land manager that are "unprecendented in the history of wildland fire control in the U.S.," Rapp says. He reiterates that FOCUS offers the capability of (1) testing the effectiveness of almost any combination of firefighting forces; (2) making an analysis of the cost-effectiveness of each plan; and (3) presenting information on the probable outcome of a fire plan, in a small fraction of the time it would ordinarily take to test the plan.

How well FOCUS works depends to a large extent upon how well the computer specialist and fire planning specialist work together as a team, Rapp says. The Riverside research group is helping FOCUS users with this and other aspects of implementing the FOCUS system.

More information about FOCUS is available from either Stan Rapp or Bill Phoenix, research liaison foresters, Fire Management Systems Unit. Both are at the Riverside Forest Fire Laboratory, USDA Forest Service, P.O. Box 5007, Riverside, CA 92507, and may be reached by phone at (714) 787-1503 (or, on FTS, at 892-9503).

— By Marcia Wood, Pacific Southwest Station

Logging and fish habitat

The April 1976 issue of *Forestry Research* carried an article on "Small Streams and Fish Habitat," describing some research on the effects of logging on anadramous fish in southeast Alaska. One of our readers, Dr. John Moring, Oregon Department of Fish and Wildlife, Corvallis, has written in response to the following statement in that article: "No one knows for sure just what effect logging has on salmon production."

Moring reports that, "Certain logging activities have been definitely shown to adversely affect salmonids in streams. Populations of cutthroat trout, for example, remained depressed for eight years after logging. Growth, survival, and migration timing of coho salmon in the streams at the time of logging were retarded."

"In addition, two more recent studies have shown that increased levels of sediment fines in the gravel results in decreased survival-to-emergence of coho salmon and steelhead trout alevins."

The following references will provide more information:

Moring, John R., and Richard L. Lantz. Alsea Watershed Study — Part I (Biological Studies). Fishery Research Report Number 9. Oregon Department of Fish and Wildlife, October 1975.

Moring, John R. Alsea Watershed Study — Part II (Changes in Environmental Conditions).. Fishery Research Report Number 9. Oregon Department of Fish and Wildlife, December 1975.

Moring, John R. Alsea Watershed Study — Part III (Discussion and Recommendations). Fishery Research Report Number 9. Oregon Department of Fish and Wildlife, December 1975.

This series can be obtained for $10.00 per set (Parts I, II, and III) from the Oregon Department of Fish and Wildlife, 303 Extension Hall, Oregon State University, Corvallis, Oregon 97331.

New national research units

Two new National Research Units have been established at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. Richard S. Driscoll is the manager of the Resources Evaluation Techniques Program, and Stanley N. Hirsch is the project leader for the National Fuel Inventory and Appraisal Work Unit.

By means of the Forest and Rangeland Resources Planning Act of 1974, Congress requires the Forest Service, through the Department of Agriculture, to work with other resource agencies to periodically assess our country's renewable natural resources for planning purposes. Information developed from assessments must be useful to Congress as well as regional and local planners. The Resources Evaluation Techniques group will seek to improve methods for renewable resource inventory and evaluation, and for storing, retrieving, and displaying data in ways that will speed and enhance multiresource planning.

The Fuel Inventory and Appraisal team will concentrate on developing a uniform method for assessing the kinds and amounts of fuel on wildlands receiving organized fire protection in the United States. Their goal is to develop a national "fire fuel hazard index" that resource managers can use as a guide to determine fuel conditions and plan ways to control dangerous situations before wildfire occurs. National Forest System and Bureau of Land Management personnel will be part of the research team.

Publications

Controlled burning experiments helped to develop the ROS equation.

Fire spread in chaparral

One important aspect of predicting fire behavior is the ability to calculate the forward rate-of-spread (ROS).

There is a new publication out which can help fire managers in southwestern oak chaparral make more accurate spread predictions and thereby control and manage both prescribed fires and wildfires more safely and effectively. "Predicting Rate of Fire Spread in Arizona Oak Chaparral" (General Technical Report — RM-24-FR8) was compiled by Rocky Mountain Station fire researchers James R. Davis of Fort Collins, Colorado, and John H. Dieterich of Tempe, Arizona.

The publication, intended for field use, contains a ROS equation, developed through actual burning experiments. Using information from tables in the handbook or direct measurements, the user determines certain factors such as leaf moisture content, air temperature, relative humidity, time of day, windspeed, etc., and incorporates them into the equation. Using a simple worksheet and hand calculator, he is able to calculate the predicted ROS for specific times and locations.

The publication contains a sample problem, tables and charts to help the user relate his field observations to the ROS equation.

It can be ordered from the Rocky Mountain Station in Fort Collins.

History of spruce budworm outbreaks

Two Intermountain Station scientists have issued a summary of information on numerous outbreaks of the western spruce budworm that damaged more than 15 million acres of forests over a period of 50 years.

The report reviews information on hundreds of budworm infestations in the West. The infestations increased fire hazards, defoliated trees capable of producing enormous volumes of wood products, and seriously depleted wildlife and recreation resources. Authors are Entomologists Philip C. Johnson, Missoula, Montana; and Robert E. Denton, Moscow, Idaho.

In the report, "Outbreaks of the Western Spruce Budworm in the American Northern Rocky Mountain Area from 1922 through 1971," (General Technical Report-INT-20-FR8), the authors discuss how location, duration, density of the insect population, and types of forest stands influence the extent of damage. Drawing on existing knowledge and the judgment of forest management specialists, Johnson and Denton have included examples of short- and long-term effects of budworm outbreaks on forest uses in the Northern Rocky Mountains. They also identify particular problems for future research.

Copies of the report are available from the Intermountain Station.

Montana forestry employment

Wages for Montana timber and wood products industry workers are well above the national average. They also lead the average for other State industries.

This information is included in an Intermountain Station report, "A Profile of Forestry Employment in Montana," authored by Richard L. Porterfield, assistant professor of forestry at Mississippi State University. The report discusses the major role that forestry-related jobs play in the total manufacturing employment picture in Montana. An analysis of productivity, annual earnings, industry safety, and personal characteristics of the work force of the industry is included. Porterfield was stationed at Missoula, Montana, as a Forest Service faculty intern at the time the report was prepared.

Porterfield notes that the higher wages are especially significant in view of Montana's economic slowdown. In 1950 per capita income was 8 percent above the national average; by 1968 it had fallen to 14 percent below the average. Also, the proportion of employees in the timber industry who worked 50 to 52 weeks a year was larger than the national average.

According to Porterfield, even though the wood products industry has led the State in new capital expenditures in recent years, employee productivity, measured in value added per employee, has remained low when compared to other industries.

Copies of Research Paper-INT-172-FR8, are available from the Intermountain Station.

Landscape evaluation

Terry C. Daniel, associate professor of psychology at the University of Arizona, and Ron Boster, former economist with the Rocky Mountain Station at Tucson, Arizona, have designed and field tested a technique for assessing allusive scenic beauty values. Their approach is reported in "Measuring Scenic Beauty: The Scenic Beauty Estimation Method" (Research Paper RM-167-FR8).

Daniel and Boster feel their technique has several strengths. First, it involves an array of people in the process of evaluating public response to landscape changes — real or planned. This process can strengthen relationships between the public and the landscape architect. Second, assessments can be made at convenient public locations using color slides representative of the landscapes under consideration. Third, true differences in perceived beauty can be identified independent of differences in personal standards held by individual observers. The technique shows promise as an objective means for assessing the scenic beauty of public forests and wildlands, and for predicting the esthetic consequences of alternative land uses.

Research Paper RM-167-FR8 has been designed for serious landscape designers as well as forest administrators. General information is printed on the outer edges of each page while details and procedures are featured in the center columns. Included is a user's manual for the computer program developed to analyze data collected in the scenic beauty estimation process. This paper can be ordered from the Rocky Mountain Station.

System to check plant dormancy

Intermountain Station scientists and a National Forest electronics technician have developed a portable system that sends an electronic signal through plant tissue to determine dormancy of nursery seedlings, trees, and shrubs.

The system is described in "Portable Oscilloscope Techniques for Detecting Dormancy in Nursery Stock," (General Technical Report — INT-26-FR8), published by the Intermountain Station. Authors are Robert B. Ferguson, Shrub Sciences Laboratory, Provo, Utah; Russell A. Ryker, Forestry

Frank Morby, nurseryman at Lucky Peak Nursery near Boise, tests seedling dormancy with portable oscilloscope.

Sciences Laboratory, Boise, Idaho; and Edward D. Ballard, Boise National Forest.

Equipment to provide readings include an oscilloscope, square wave generator, electrode, and connecting cables. Instruments are carried in a compact carrying case. The complete system, weighing about 15 pounds, provides plant readings in less than 30 seconds after the units are connected and controls set.

When the electrode needles are inserted firmly into a plant, electrical waves appear on the screen of the oscilloscope. The shape of the waves tells whether the plant is actively growing, dormant, or dead.

The technique had been used since 1974 to determine dormancy of planting stock before fall lifting at the Forest Service's Lucky Peak Nursery near Boise, Idaho. The Nursery supplies seedlings to 16 National Forests in the Intermountain Region, to cooperating agencies in southern Idaho, and to the Southwest Region of the Forest Service for planting in Arizona and New Mexico.

The report, available from the Intermountain Station, describes the equipment used in the system and lists component manufacturers.

Root manipulation in the seed bed

When seedlings raised in forest nurseries develop efficient root systems, they are hardier and survive better when planted in the forest. Techniques to encourage fibrous root systems, and to prevent deep tap root growth and seedling height growth have been promoted since 1935. The techniques — undercutting and wrenching — are now being studied on Douglas-fir at the Wind River Nursery near Carson, Washington, and on ponderosa pine at the Dwight L. Phipps Nursery near Elkton, Oregon.

The seedlings are first conditioned by undercutting, a procedure in which the tap roots are cut off by passing a sharp blade under seed beds. This is followed by passing a thicker, broader, tilted blade beneath the seed bed (wrenching) to aerate the root zone. This process is repeated at 1- to 4-week intervals during the growing season.

James W. Edgren, plant ecologist at PNW Station, reports on "Wrenching — Recent Developments in an Old Technique," in the Proceedings of Western Forest Nursery Council Meeting, August 1974. Reprints are available from Publications Distribution, PNW Station.

Grazing under the pines

Land managers trying to decide whether to seed forage grasses on forested or open range land can get help from two recent publications from the PNW Station.

The advantages of combining timber and forage production in thinned ponderosa pine stands of eastern Oregon and Washington are outlined in a publication based on the 1974 stocking guides for Forest Service Region 6, and PNW Station research. The stocking guides recommend thinning to a density that creates an open forest which grows at an accelerated rate, with fewer, but larger trees. These thinned stands have the potential to produce forage for cattle without reducing timber growth. Natural forage production can be increased if grasses are

planted in soils disturbed by timber harvest operations.

Copies of "Important Range Implications of New Ponderosa Pine Stocking Guides," by Robert Sassaman, Louis R. Spink, and Asa D. Twombly, are available from the Range Management Section, Forest Service, Region 6, P.O. Box 3623, Portland, Oregon, 97208.

After the decision to thin has been made, managers may find it advantageous to invest in grass planting. Two PNW Station economists have developed a method for figuring the potential rate of return on such an investment. The return is based on the adjusted market value of an animal unit month (AUM) of grazing and the capital costs of forage production over and above the usual thinning expenses.

"A Tool for Estimating the Financial Returns on Forage Grasses Seeded in Thinned Ponderosa Pine," by Robert Sassaman and Roger Fight, appeared in the *Journal of Range Management,* (28(3):185-189). Reprints are available from Publications Distribution, PNW Station.

Producing raw materials for particleboard from wood now left in forests as logging residue, a goal of forest managers and researchers, would add to costs, Withycombe observes. When available mill wastes are exhausted, he expects new particleboard plants to first locate near markets and heavy concentrations of forest residue — probably in the South and on the Pacific Coast.

Similar plants in the Northern Rocky Mountains would have no advantage over others, and thus manufacture of conventional particleboard from forest residues in this region is expected to lag behind the rest of the nation.

Although particleboard cannot be made from fine mill wastes, the forest residues of the Northern Rockies may be in greater demand if markets for structural particleboard should expand. This product cannot be made from fine mill wastes and the forest residues of the Northern Rockies would be suitable.

Withycombe's research was sponsored by the Intermountain Station as part of its Forest Residues Utilization Program. His report is available from that Station.

Particleboard production for northern rockies

Particleboard production will continue to be a growth industry, and the Northern Rocky Mountain region has the potential for several new plants in the near future, according to a University of Montana researcher.

Richard P. Withycombe, assistant professor of management, analyzed the outlook for particleboard in a report entitled "The Outlook for Particleboard Manufacture in the Northern Rocky Mountain Region," (General Technical Report-INT-21-FR8).

The Northern Rocky Mountain region now has several plants in Idaho and Montana that make particleboard or similar products. Withycombe expects new plants to use mill wastes from sawmills, plywood mills, and other primary wood processors.

Recreation and aspen mortality

Numerous campgrounds have been constructed in aspen stands in the Western United States. Unlike other trees, the bark of western aspen is smooth, soft, and a living part of the photosynthesis process. The tree is extremely susceptible to damage, and trunk wounds are common. Wounds cause physical damage to tree functions and are the common entrance points for canker diseases, the most serious cause of aspen mortality.

T. E. Hinds, research plant pathologist at Fort Collins, Colorado, has recently authored a Research Paper entitled "Aspen Mortality in Rocky Mountain Campgrounds" (RM-164-FR8). It is the first comprehensive study of aspen deterioration due to people concentration in recreation areas. In this

study, 17 campgrounds containing 422 campsites were examined.

Mechanical injuries — usually deliberate cuts in the bark inflicted by knives, hatchets, and axes — were found on at least half of the aspens. In some campgrounds, every tree near each campsite was injured, revealing vandalism of epidemic proportions.

Wounded trees frequently die within 5 to 10 years. The verdant aspen stands, that were a major reason for developing these recreation sites, will probably vanish within 50 years. The future for aspen campgrounds appears bleak.

Two management implications are concluded from this study: (1) future campgrounds should be constructed in a more durable forest-type, and (2) interpretive signs need to be displayed in existing aspen campgrounds to show users why they should protect these trees.

Copies of Research Paper 164 may be ordered from Rocky Mountain Station.

Recreation vs. water quality

"There is no association between increasing levels of bacterial water pollution and increasing levels of camper concentrations in campgrounds." This is one of several conclusions reached by Dr. Robert Aukerman and William T. Springer, Department of Recreation Resources, Colorado State University, in their recent Eisenhower Consortium Bulletin 2 titled "Effects of Recreation on Water Quality in Wildlands."

The basic purpose of the study was to monitor and evaluate the effects of concentrations of various types of campers on wildland water quality. The study centered on campgrounds throughout the Cache La Poudre watershed in the Colorado Front Range west of Fort Collins. This area was chosen because of its similarities to other recreation areas in the western states.

Even though changes in water quality did not correlate with changes in numbers of recreation users, Aukerman and Springer found that various types of campers and campground designs correlated with increased pollution loads. The authors recommend certain measures be taken to prevent potential pollution. One interesting recommendation is that recreation managers should strive to concentrate campers as much as possible to diminish the threat of pollution from careless or inconsiderate action on the part of the recreationists.

Other conclusions in this report will be of interest to land use planners, and recreation and water-supply managers. A copy of the report may be obtained by sending $4 to the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia, 22151. Request Bulletin #2 — PB251104.

Keep a close watch for our next issue. Feature articles will include: management of western larch forests; mule deer management; prescribed fire; and dwarf mistletoe.

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